Increasing prolificacy of the fat tail Awassi sheep using the Booroola *FecB* gene

E. GOOTWINE
INSTITUTE OF ANIMAL SCIENCE
THE VOLCANI CENTER
AGRICULTURAL
RESEARCH ORGANIZATION
BET DAGAN
ISRAEL

SUMMARY - The Awassi is the main type of sheep in the Middle East, where it is kept under a wide range of production systems. The prolificacy of the Awassi is low - about 1.2 lambs born per ewe lambing (LB/EL). To increase prolificacy without adverting the Awassi phenotype and adaptability, a scheme was initiated in 1986 to introduce the *FecB* (Booroola) gene into the Awassi. Results so far show that lamb production in Booroola Awassi crosses carrying one copy of the *B* allele is about 2.0 LB/EL and that milk production is not affected by the Booroola gene. Distribution of *BB* or *B+* Awassi rams in Awassi flocks can dramatically increase their productivity. DNA markers linked to the Booroola gene can be used in selection of lambs carrying the gene.

Key words: Awassi, Booroola, lamb production, milk production

RESUME *- La mouton Awassi est le type ovin principal du Moyen-Orient, et est utilise dans des systemes de production divers. Sa prolificite est basse, 1.2 agneaux / agnelage approximativement. Pour augmenter cette prolificite sans modifier la phenotype Awassi et son adaptabilite, un programme a ete mis en place en 1986 pour introduire chez l'Awassi le gene FecB (Booroola). Les resultats obtenus montrent que la production d'agneaux du croisement Booroola Awassi porteur de l'allele B est d'environ 2 agneaux / agnelage et que la production de lait n'est pas affectee por le gene Booroola. La distribution de beliers BB ou B+ dans les troupeaux Awassi pourrait accroitre de facon dramatique leur productivite. Des marqueurs genetiques lies au gene Booroola peuvent etre utilises pour identifier et selectionner les agneaux porteurs du gene.*

Mots-clés: *Awassi, Booroola, production d' agneaux, production laitiere*

INTRODUCTION

The Awassi is the main type of sheep in the Middle East, where it is raised for meat, milk and wool. In Israel, there are about 300,000 Awassi sheep that are kept under a wide range of production systems: from nomadic flocks relying on sparse natural pasture in semi-arid areas, to dairy flocks where the Improved type is kept in intensive indoor units (Epstein, 1985). The Awassi is known for its hardiness and adaptability to the local environment and, in the case of the Improved Awassi, also for its high milk production. Yet, prolificacy of the Awassi is low - about 1.2 lambs born per ewe lambing (LB/EL). As lamb production is an important source of income in all flocks, increasing the fecundity of the Awassi has always been an important breerding goal.

Previously, the Awassi was crossed the with East Friesian breed, resulting in the development of the Assaf (Goot, 1966), which became the main dairy breed in Israel, and has been exported to some other Mediterranean countries. The prolificacy of the Assaf is higher than that of the Awassi - about 1.6 (LB/El). However, experience has shown that the Assaf is less adaptable than the Awassi and is more successful under intensive conditions. Further increase in prolificacy - up to about 2.0 LB/EL - was obtained in Awassi crosses with the Finn and the Romanov breeds (Goot *et al.*, 1980). However, those crosses have never been used in dairy flocks and have had only a marginal impact on the semi-intensive sheep industry in this country, mainly because of the preference for the traditional Awassi fat-tailed phenotype among the local breeders and consumers.

In 1986, a scheme was initiated to introduce into the Awassi the *B* allele of the *FecB* gene (Gootwine, 1985). The *FecB* is a major gene that affects the ovulation rate in sheep and on the average, one copy of the *B* allele increases the ovulation rate by 1.2 ova shed per ewe ovulating and the lambing rate by 0.6 lamb born per ewe lambing (Piper *et al.*, 1985). The objective of the breeding plan was to obtain a prolific Awassi-type fat-tail breed with potential for high milk production. This genotype named *Awassi+*, with average prolificacy of over 2.0 LB/EL will be suitable for both dairy and non-dairy, intensive or semi-intensive production units. Due to its traditional fat-tailed Awassi phenotype, it is expected that the *Awassi+* can be easily introduced and accepted by most of the traditional Awassi sheep breeders in the Middle East.

The aim of the present communication is to describe the Booroola-Awassi breeding plan, to summarize the results obtained so far in terms of lamb and milk production, and to discuss the possible social-economic impact of using the *Awassi+*.

THE BREEDING PLAN

The Booroola Awassi breeding program is described in Fig. 1. Its main features are:

A. Production of F1 *B+* rams by crossing Awassi ewes with *BB* homozygous Booroola-Merino rams;

B. two or three backcrossing steps to the Awassi in which about 50 *B+* ewes are produced in each generation;

C. identifying *B+* BC2 rams by progeny testing;

D. a final intercross phase and fixation of the *B* allele on a background of 90% or more Awassi blood.

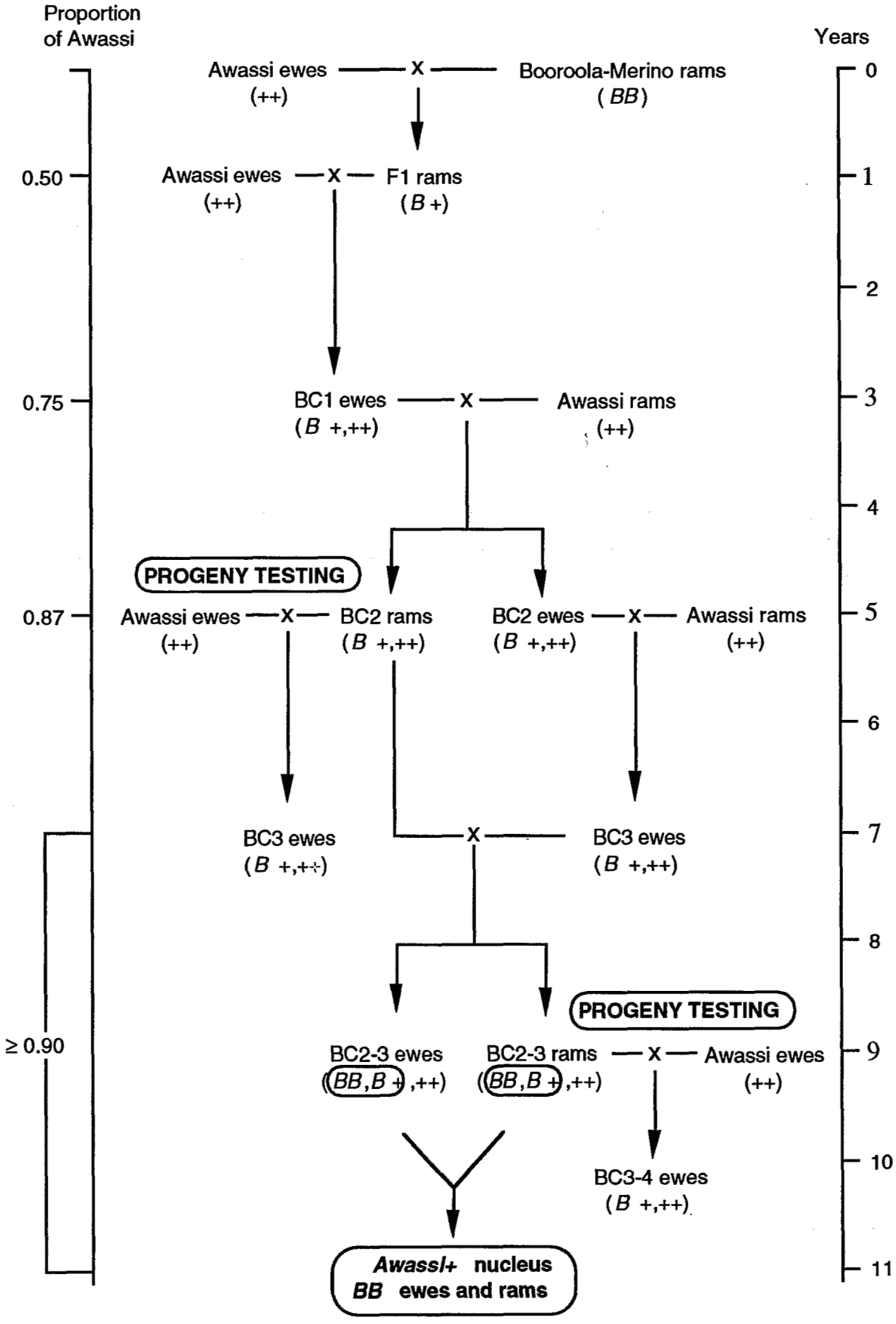
Identification of ewes carrying the *B* allele among the Booroola Awassi crossbreds is based on four or five records, comprising lambing records up to the 3rd lambing and one to two ovulation records. Crossbred ewes that have recorded litter sizes or ovulation rates of three or more are classified as *B+*. Other ewes are assigned as ++. The accuracy of this selection criterion is estimated to be 99% in identifying *B+* individuals. According to the original plan, *B+* BC2 rams had to be selected by progeny testing. However, as molecular genetic markers linked to the Booroola gene became available (Montgomery *et al.*, 1993), selection of all BC2 ram and some of the BC2 and BC3 ewes is based on those markers (Gootwine *et al.*, 1994a).

DESCRIPTION OF THE MANAGEMENT SYSTEM OF THE BOOROOLA AWASSI PROGRAM

General management and feeding regime

The crossbreeding work is carried out with the Ein Harod Improved Awassi dairy flock which includes some 1300 ewes. This flock is kept indoors all the year round and is fed according to the Israeli Ministry of Agriculture recommendations (Landau and Leibovich, 1992). Feeds included concentrates, barley grains, cotton

Fig 1: Crossbreeding plan for the introgression of the Booroola gene into the Awassi



seeds, rye grass, vetch hay and corn silage. In the spring, the ewes graze for about 2h/day on natural or artificial pasture. Six to eight people work with the flock each day. Lamb and milk production, respectively, contribute about one third and two thirds to the gross income.

Reproduction

During four 34-day periods (May-June; August-September; October-November; December-January), ewes are checked daily for estrus and those in heat are hand-mated. Hoggets are mated for the first time at approximately 8-10 months of age, after being treated with progestagen intravaginal sponge and 600 IU of pregnant mare serum gonadotrophin. About half of the hoggets conceive following the hormonal treatment, which does not affect prolificacy, while the other hoggets conceive in the following naturally occurring cycles.

Lambing

At the lambing periods, ewes are observed for 18 h per day and are assisted with difficult lambings. On the day of lambing, each lamb is weighed and moved to an artificial rearing unit, where commercial milk replacer is offered *ad libitum* until weaning at approximately 1 month of age. Lambs are marketed at about 5 months of age, at about 45-50 kg; the selling price is about $US 3-4 / kg live weight.

Milk production

From the day of lambing, ewes are milked twice daily until their milk yield drops to approximately 0.5 l/day or when they have to be dried off before lambing. Milk yield is recorded monthly. The price for milk is about $US 0.8 / l.

Data Recording

Recording of the breeding, lambings and milk production of the Booroola crosses is done by the Ein Harod staff as part of the routine flock work. Data collection and processing are computerized. Recently, the newly developed "Ewe and Me" software (Gootwine, 1994b) has come into use.

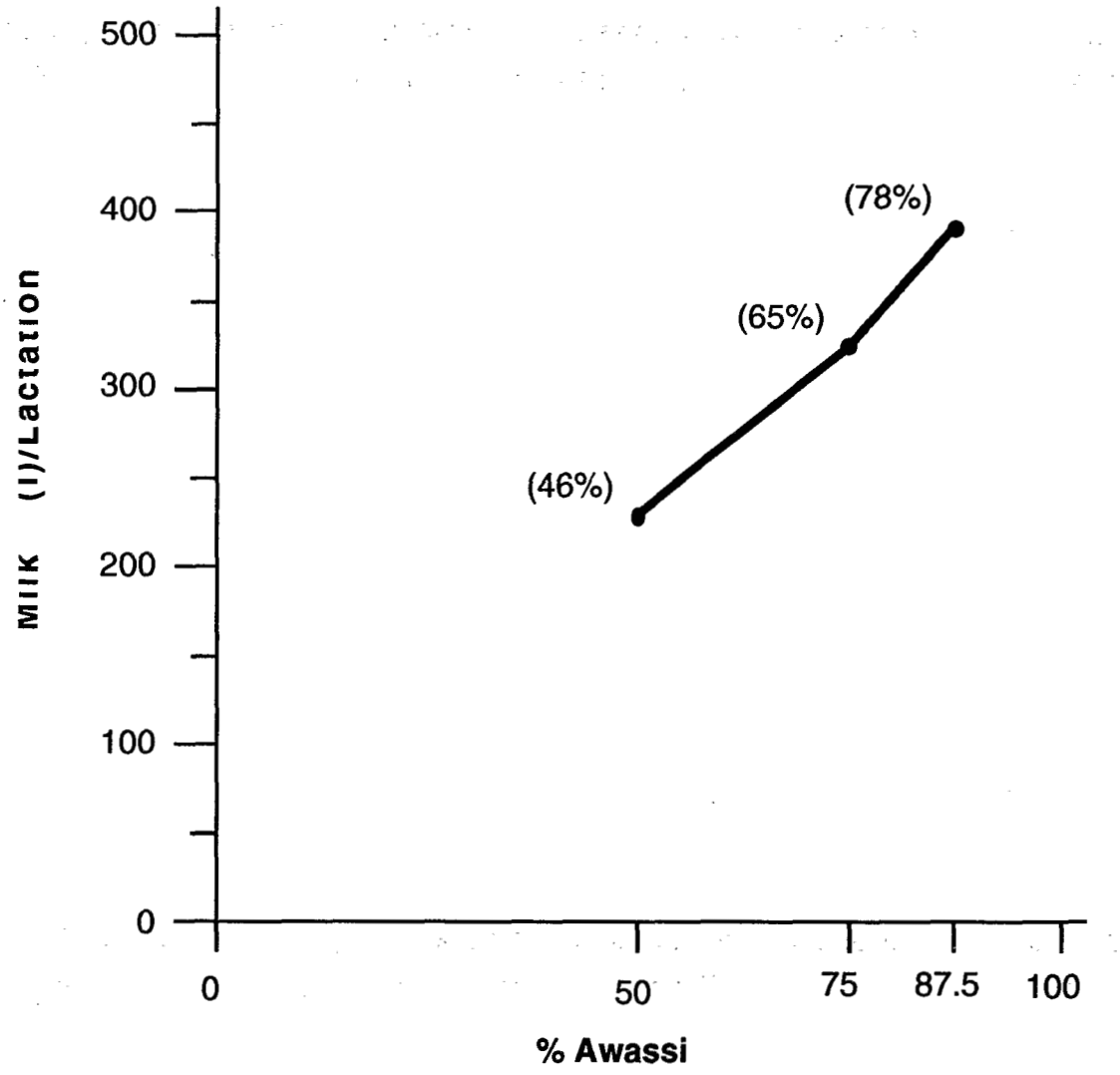
RESULTS OBTAINED SO FAR

Lamb production

The average prolificacy of Awassi ewes in Ein Harod up to the third parity is 1.28 LB/EL with 0.96 of the lambs being born alive. Prolificacy of *B+* crossbred

Booroola Awassi ewes is about 2.0 LB/EL, of which 1.7 lambs are born alive (Gootwine *et al.*, 1995). The effect of carrying one copy of the Booroola gene in the Booroola Awassi crosses is similar to what has been reported for other Booroola crosses (Piper *et al.*, 1985) as well as in the Booroola Assaf cross (Gootwine *et al.*, 1993). The prolificacy of the *BB* Booroola Awassi crossbred will be investigated only at the final stage of the crossbreeding. However, it is expected that lamb production will be even higher than in *B+* ewes. Lamb birth weight in Booroola Awassi crosses was not different from that in the Awassi, although, as prolificacy increased, the average birthweight in the Booroola crosseswas found to be lower than that in the Awassi.

Fig. 2. Changes in milk production in Booroola-Awassi crosses thru backcrossing to the Awassi.



Milk production

Milk production of Awassi ewes in the Ein Harod flock is about 500 l per lactation. Milk production of F1 Booroola Awassi crossbred ewes was lower than that of Awassi ewes by almost half (Gootwine *et al.*, 1995). However, it is increasing as upgrading to the Awassi progresses (Fig 2). Reduction of the milk production of the Booroola crosses as compared with that of the pure Awassi was not caused by the Booroola gene but by other Merino genes (Gootwine *et al.*, 1995).

PROJECT MANAGEMENT AND COSTS EVALUATION

Development of the *Awassi+* is a joint venture of the Sheep Department at the Volcani Center and Kibbutz Ein Harod, and is within the framework of a comprehensive R&D project where the Booroola gene is also being introduced into the Assaf and the German Mutton Merino breeds. Studying the effect of the Booroola gene on the sheep physiology and research into the inheritance of productive traits in the Booroola crosses are the scientific objectives of the project. Increasing lamb production in the sheep production units will be the practical contribution. It is, therefore, difficult to evaluate precisely the cost of development of the *Awassi+, per se*. However, taking into consideration the costs of importating the Booroola rams, genotyping of some 400 individuals through the 10-11 years of the project and of compensation for revenue losses caused by lower milk production of the Booroola-Awassi crossbreeds, it is estimated that project costs till its termination will be around $US 70,000.

DISCUSSION

Mutton and lamb consumption in the Middle East is one of the highest in the world. As the local production is far below the demand, the market for lambs is practically unlimited, at a price of $US 2.5-3.0 / kg live weight, or even more. There are some tens of millions of Awassi and Awassi-related, low-prolific sheep in the region. Introduction of the Booroola gene, by distribution *BB* or *B+ Awassi+* rams or semen, could dramatically increase lamb production without necessarily increasing the size of the breeding stock. In such a breeding plan, costs for developing of an *Awassi+* nucleus is negligible as compared with the expected economic benefit in the future. The high net return from increasing lamb production - about $US 100 for every additional lamb - would even economically justify the utilization of DNA markers for screening for *B* carriers among lambs.

Most of Awassi flocks are maintained under nomadic extensive management conditions, and their productivity is limited by the pasture available. In many cases, feed supplementation or investment to improve health or housing of the stock is not economically justified owing to the low reproductive potential of the Awassi, that even under optimal conditions will not produce more than 1.2-1.3 lambs per lambing. Introducing the Booroola gene into those Awassi flocks would increase their owners' income within a short time which, in turn, would justify moving into a more intensive production system in which lamb survival and reproduction rate of ewes would be increased. One of the possible socio-economically important benefits of intensification of the sheep industry in the region could be removal of the necessity for nomadic migration.

REFERENCES

Epstein, H. (1985). *The Awassi sheep with special reference to the improved dairy type* Animal Production and Health Paper No. 57, FAO, Rome.

Goot, H. (1966). [Studies on the native Awassi sheep and its crosses with the exotic East Friesian milk sheep]. Special Publication No. 115, The Volcani Center, A.R.O., Bet Dagan, Israel. (in Hebrew).

Goot, H., Foote, W.C., Eyal, E. and Folman Y. (1980). *Crossbreeding to increase meat production of the native Awassi sheep.* Special Publication No. 175, The Volcani Center, A.R.O., Bet Dagan, Israel. .

Gootwine, E. (1985). [Assessment of sheep breeding policy in Israel.] Hassadeh 65: 1451-1455. (in Hebrew).

Gootwine, E., Braw-Tal, R., Shalhevet, D., Bor, A. and Zenou, A. (1993). Reproductive performance of Assaf and Booroola Assaf crossbred ewes and its association with plasma FSH levels and induced ovulation rate measured at prepuberty. Animal Reproduction Science, 31: 69-81.

Gootwine, E., Bor, A., Braw-Tal, R., Ofir, R., Yossefi, S., Zenou, A., van Stijn, T.C., Penty, J.M. and Montgomery, G.W. (1994a). Identification of FecB carriers among Booroola-Awassi crosses using the OarAE101 microsatellite marker. Proc. 5th World Congress on Genetics Applied to Livestock Production, Guelph, Canada, 22: 260-263.

Gootwine, E., Leibovich, H., Waisel, G., Zenou, A. and Spormas, I. (1994b). 'Ewe And Me" On farm software for dairy and mutton sheep and goats flocks. Proc. 5th World Congress on Genetics Applied to Livestock Production, Guelph, Canada, 22: 67-68.

Gootwine, E., Bor, A., Braw-Tal, R. and Zenou, A. (1995). Reproductive performance and milk production of the Improved Awassi breed as compared with its crosses with the Booroola Merino. Animal Production, 60: (in press).

Landau, S. and Leibovich, H. (1992). [Nuitritional requirements of sheep] Israel Ministry of Agriculture, Extension Services, Tel Aviv (in Hebrew).

Montgomery, G. W., Crawford, A. M., Penty, J. M., Dodds, K. G., Ede, A. J., Henry, H. M., Pierson, C. A., Lord, E. A., Galloway, S. M., Schmack, A. E., Sise, J. A., Swarbrick, P. A., Hanrahan, V., Buchanan, F. C. and Hill, D. F. (1993). The ovine Booroola fecundity gene (*FecB*) is linked to markers from a region of human chromosome 4q. *Nature Genetics* , 4: 410-414.

Piper, L. R., Bindon, B. M., & Davis, G. H. (1985). The single gene inheritance of the high litter size of the Booroola Merino. Genetics of Reproduction in Sheep. R. B. Land and D. W. Robinson (eds). Butterworths, London, pp. 115-125.